

An examination of product innovation in low- and medium-technology industries: cases from the UK packaged food sector

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Abstract

This study deepens our knowledge of organisational routines and activities in the innovation process of low- and medium-technology (LMT) industries. To accomplish this, it explores how the innovation process in the packaged foods sector of the UK food industry depends on a learning- by-doing, by using and by interacting (DUI) mode of innovation including activities such as technology adaptation and the use of external firm sources. The empirical analysis is based on four case studies of new product innovation taken from a cross section of the packaged foods sector. Our findings support the view that LMT industries rely on non-formal Research and Development (R&D) activities such as firm interaction and shared experiences. We develop a set of propositions which help to explore evidence in practice of how these external sources influence the innovation process. Our research contributes to theory in the areas of innovation processes in low- and medium-technology (LMT) industries and DUI industrial modes of innovation.

1. Introduction

Researchers have recognized the unique characteristics of innovation in the food industry since at least the early 1980s (Ettlie 1983). Since this time much research has shed light on our understanding. Significant amongst these findings is the recognition that in low and medium technology (LMT) intensive industries the traditional science and technology model of innovation is not applicable and cannot explain continued product and process innovations (see Bush, 1945; Maclaurin, 1953; Arrow, 1968; Pavitt, 2001; Fitjar and Rodriguez-Pose, 2013). Further, in the classic article by Pavitt (1984: 343–373) he spelt out, in his typology of firms, that ‘LMT industries are characterised by process, organisational and marketing innovations, by weak internal innovation capabilities and by strong dependencies on the external provision of machines, equipment and software’. LMT sectors are central to economic growth. Whether measured in terms of output, capital invested or employment, they dominate the economies of highly developed as well as developing nations, providing more than ninety percent of output in the European Union, the USA and Japan¹. Given this dominant position within modern industrialised economies attempting to better understand the nature of innovation within this sector is of concern to policy makers and industrialists.

The role of low technology intensive firms and industries in modern economies is complex and frequently misunderstood (Robertson et al., 2009). This is partly due to Hatzichronoglou’s (1997) widely used revision of the OECD classification of sectors and products, which only refers to high technology (defined as spending more than five per cent of revenues on R&D). This has contributed to an unfortunate tendency to understate the importance of technological change outside such R&D-intensive fields (Hirsch-Kreinsen et al., 2006; Robertson et al., 2009). Products and production processes in these industries may be highly complex and capital intensive. The food industry is frequently classified as a low tech intensive industry. Research in the area of low technology intensive industries shows a dominance of incremental, mostly process driven innovations where disruptive innovation activities are scarce. Research within the food and agriculture sector has demonstrated the importance of collaboration amongst members of the food provision system, and close network linkages (e.g. Kuhne et al., 2015; Karantinis et al., 2010; Devaux et al., 2009; Fritz and Schiefer, 2008; Menrad, 2004). Table 1 provides an overview of key economic data indicators which shows the food industry as the largest manufacturing sector and clearly characterises it as a low technology sector.

Table 1: Overview of economic data indicators from the UK food industry

Indicator	2014
Turnover	£80 billion
Exports	£12.6 billion (77% to EU)

¹ General treatments of the role of LMT firms and industries are given in Von Tunzelmann and Acha (2005), Sandven et al. (2005) and Robertson and Patel (2007). Hirsch-Kreinsen et al. (2006) report on a European Commission study of LMT sectors.

Manufacturing	16% of all UK manufacturing; Over 6000 manufacturing firms, the largest sector in UK
Imports/exports	24 countries together accounted for 90% of UK food supply
Agriculture	Two thirds of all the UK's agricultural produce goes into UK food manufacturing
R&D	£1.1 billion on R&D (% of revenue on R&D is 0.014%)
Innovation and new products	8000 new product launches
Food manufacturing and processing	The sector consists of several smaller sub-sectors including meat and fish processing, poultry, frozen, ambient, chilled and prepared foods, dairy, soft drinks, bakery, brewing, distilling, fresh produce, milling and cereals, sweets and confectionery.
Employment numbers are dominated by:	Skilled trades' occupations; machine and transport operatives; and elementary occupations.
Education and training	The sector is less well qualified compared with the UK population ² . Some industries in this sector have a high proportion (more than 65%) of low qualified workforce.

Sources: <http://www.focusmanagementconsultants.co.uk/food-industry-information>

National Guidance Research Forum: <http://www.guidance-research.org/future-trends/food>

The food industry has traditionally experienced very low levels of investment in R&D yet has delivered both product and process innovation over a sustained period. Avermatete et al. (2004) argue within the food industry R&D financial effort is a poor indicator of innovation intensity due to specific features of its innovation pattern, such as process orientated and a reliance on technologies developed by upstream industries. In such environments innovation can be explained through learning by doing and the use of networks of interactions and extensive tacit knowledge (Lundvall, 1992; Nonaka and Hirotaka 1995). Similarly, Jensen et al (2007) characterised a learning by 'learning-by-doing, by-using, and by interacting' (DUI) mode of innovation where extensive on-the-job problem solving occurs and where firms interact and share experiences. More recently, Fitjar and Rodriguez-Pose, (2013) developed a classification of DUI firm interactions in a study of firm level innovation in the food industry in Norway. They found that '*firms which engage in collaboration with external agents tend to be more innovative than firms that rely on their own resources for innovation*' (Fitjar and Rodriguez-Pose, 2013: 137).

Our study focuses on food packaging innovations, which are of growing importance within the highly competitive food industry. This sector is characterised by high integration between the packaging and the product, which is not so in other **product categories** such as smart phones. Firms in the packaged foods sector are increasingly utilising packaging innovations to differentiate and improve the performance of their products (Wells *et al.*, 2007; Mahalik and Nambiara, 2010). Consequently, it has been suggested that packaging is a 'priority issue' within new product development (NPD) (Koss, 2007, p. 132; Johnsson, 1998). A number of factors have contributed to this growing significance of packaging processes: (i) government and consumers concerns of the impact of packaging on the environment (Prendergast and Pitt, 1996; Thøgersen, 1999; Rundh, 2005); (ii) increased logistics costs (Rundh, 2005; Lockamy, 1995); and (iii) the expanding competition from retailer brands (Vazquez *et al.*, 2003; Burt, 2000). Yet, packaging has received relatively little attention and theory in this area is underdeveloped. This research offers an empirical study on how firms manage packaging within their NPD activities. The case studies offer new insights into how packaging forms an integral part of the food product that is inseparable from the core product (e.g. Simms and Trott, 2014; Wells *et al.*, 2007; Rundh, 2005; Silayoi and Speece, 2004).

The purpose of this paper is to examine one industry sector, the packaged foods sector of the UK Food Industry, and examine product innovation and see whether DUI industrial modes of

² 52% of the UK Improve workforce has a Level 2 qualification or below. Around 15% of the workforce is qualified to Level 4 or higher.

innovation offer a better understanding of innovation within this low technology intensity industry. A criticism of previous studies within LMT industries is their use of existing data sets from prior studies. Indeed, in a special issue on LMT in Research Policy (Robertson et al., 2009: 446) called for 'detailed studies of individual sectors to help to sort out the effects in practice'. Specifically we address the research question: how does the food supply chain use DUI to deliver product innovation in the UK packaged food sector?

Our findings are based on four in-depth product innovation case studies taken from a cross section of the packaged foods sector. This includes a large retailer; a food packaging supplier and a brand management company. We find evidence in practice of DUI modes of innovation. We uncover diffusion of technology from high tech sectors to the packaged food industry. We show new knowledge being created and illustrate the role of middle managers as agents of technology change. The paper contributes to the stream of literature on models of innovation and DUI mode of innovation (Jensen et al (2007; Fitjar and Rodriguez-Pose, 2013; Aylen, 2013). Significantly, it also contributes to sector analysis in the packaged food industry by offering insight into product innovation management in low- and medium-technology (LMT) industries (Robertson et al., 2009). The paper is structured as follows. Firstly, we review the literature on LMT innovation, this section shows that LMT industries show a dominance of incremental, mostly process driven innovations. The next section of the paper describes our case study research design. After this the findings and analysis of the four cases are presented. Finally, the limitations of the article are discussed as well as conclusions and possible directions for future research.

2. Theoretical review

2.1 Innovation within low technology intensive industries

The North American view of innovation being driven by investments in science and technology has dominated policy making within innovation³. This view, however, does not explain successful economic performance and innovation elsewhere, such as in Denmark and Norway, (Gertler and Asheim, 2006), and of specific regions in the south of Europe such as Central and Northeastern Italy, which generate good economic performance on the basis of a different set of innovation drivers (Becattini, Bellandi, and Propri, 2009; Asheim and Parrilli, 2012). The increase in competitiveness due to learning-by-doing may partly explain this good innovation and economic performance. This approach has been developed by Lundvall (2010) and others to include the interactive driver as a means to co-develop and transfer relevant knowledge within the organization (Kline and Rosenberg, 1986) and among firms (Pavitt, 1984; Lundvall, 1992).

The LMT sectors of major economies are continually being renewed as growth industries driven by scientific and technologically-based innovation (STI) such as software and electronics replace past industries that were once drivers of change (Kondratieff, 1979). This economic transformation is a dynamic process where the technology intensive industries interact with LMT sectors to deliver growth and development. LMT firms such as those involved in food processing are often major customers of high tech innovators, but significantly this technology is embodied in the equipment they purchase (Pavitt, 1984). Effective innovation by LMT firms seems to rely on adapting this equipment to meet specific requirements of the firm (Rosenberg, 1963). It is this adaption that is undertaken on the basis of learning-by-doing and learning-by-using to deliver the customised products and production processes required. These improvised changes contain

³ Benoit Godin has written extensively on the intellectual history of innovation. His work provides a detailed account of the development of the category of innovation. In his papers "Innovation Studies: The development of a speciality I and II" (Godin, 2010) he explains how two traditions emerged. The first in the USA was concerned with technological change as the use of inventions in industrial production and the second in Europe which was concerned more specifically with commercialised invention.

considerable creativity and provide the potential for the development of new knowledge, but significantly these activities while essential for innovation are not recognised in the formal statistical measurements used for R&D (Patel and Pavitt, 1994).

One of very few detailed studies of firms within the food sector was provided by Peers Hull Kristensen (1989). Significantly, this study was an early recognition of innovation relying on firm interaction and sharing knowledge and experiences. In Denmark an advanced agrarian-industrial complex evolved around the manufacturing of agricultural products and production of machinery for agriculture. Kristensen identified different industrial models within the Danish food industry. One was export-orientated, R&D-loaded, high-technology companies and the other more labour intensive employing traditional technology and mainly orientated towards the domestic market.

DUI is compatible with Schumpeterian understanding of innovation in that the core process of innovation is 'knowledge recombination'. DUI is based upon the central idea of knowledge recombination among diverse knowledge and practice sets (Jensen et al., 2007; Fitjar and Rodriguez-Pose, 2013). That is, innovation comes from the creative recombination of modules (Henderson and Clark, 1990). The DUI mode takes place, for example, in everyday work-related situations, in interaction with customers and partners or when a product or a process is used. Scientific and technologically-based innovation (STI) is a rather rare phenomenon in most industries and even among the high-technology industries only 26% of learning is mostly based on science (Lundvall and Lorenz, 2011). According to Jensen et al. (2007) the most innovative results are achieved when both the STI and the DUI modes exist at the same time, i.e. when science-based learning is combined with experience-based knowledge. This is confirmed by later studies in Norway (Aslesen et al., 2011) and China (Chen et al., 2011). The study by Dahl-Fitjar and Rodriguez-Pose (2012) suggested more nuanced findings regarding international and local firm interactions and DUI performance; and Parrilli and Elola (2011) found that such combination may not be the most effective in all contexts (see also recent study by Parrilli and Heras, 2016). Similarly a study of two wine industry clusters in Italy and Chile by Giuliani and Arza (2009) revealed that not all university-industry linkages were valuable in delivering benefit. They found that those linkages that led to the diffusing of knowledge to other firms in their regional economy were dependent on specific firm knowledge bases.

The scientific and technologically-based innovation (STI) mode supports interactions with centres producing new knowledge, such as research centres and universities, which generate the codified and explicit knowledge that can be used by the firm to produce innovations (Fitjar and Rodriguez-Pose, 2013; Jensen et al. (2007). This approach tends to generate analytical knowledge (i.e. scientific principles, discoveries, and formulas) and, to a lesser extent, synthetic knowledge bases (i.e. recombination of different analytical knowledge bases with a practical, engineering-based purpose; see Asheim and Coenen, 2006). Thus learning and innovation is based on science and technology drivers such as: R&D expenditure, Human capital in S&T disciplines, and Investment in infrastructures.

Clearly LMT firms do invest in R&D, but less as a percentage of revenues. Significantly, however, they invest in production processes that have impact across the sector (Sandven et al., 2005; Kirner et al. 2009; Heidenreich, 2009). Frequently the improvements in productivity result from the utilisation of embodied technology supplied by the high-tech sectors. For example, in process industries, development activities take place within a production line or plant environment rather than in at an R&D centre or design office. This means there are no prototypes, rather the plant is run and outputs tested. This is fundamentally different from other industries. It is experimental by nature with emphasis on manipulating the plant to deliver the required outcome. Aylen (2013) has shown how innovation continues through process 'stretch'. The R&D-manufacturing interface is the creative force. Product and process development occurs simultaneously often with significant input from machine tool manufacturers and tooling

engineers. In the packaged food sector suppliers of raw materials are key contributors during the early design and concept creation phases of process development. Indeed, much of the activity is iterative trial-and-error to reduce uncertainty (Frishammar et al., 2013).

Generally, the dominant pattern of technological development in low technology intensive industries is characterised by a high path-dependency which is continuously stabilised by incremental innovation activities. High returns on investment are generated from continuous optimisation of processes and of the existing technologies, thereby reinforcing the development paths (Cohendet and Llerena, 2010; Malerba, 2010). For example, the technologies being employed are well known and established and the processes and products are embedded in routines. This familiarity with the technologies extends to markets and customer preferences. This leads to a situation where companies continuously optimise their processes and technologies rather than pursue radical or risky innovation activities (Bunduchi and Smart, 2010; Aylen, 2013). In their study of innovation in the packaged food sector Francis et al. (2008) characterises the industry as high volume, multi product, and high variety NPD. Furthermore, an orientation toward cost minimisation is particularly apparent in this type of industry where price-based competition is high (see Utterback and Abbernathy's innovation lifecycle, 1975). This results in an emphasis on minimising costs and improving production efficiency within NPD. The cost implications of adopting new technologies therefore become significant; high capital costs, development costs, and switching costs (Bunduchi and Smart, 2010) can prevent progression. A combination of these factors can also lead to an environment in which incremental and exploitative innovation dominate over long term and substantial technological changes (e.g. Benner and Tushman, 2003; Chu et al., 2009).

2.2 Supply chain knowledge inputs

Given the finding by Fitjar and Rodriguez-Pose (2013) that DUI modes of interaction outside the supply-chain tend to be irrelevant for innovation it is necessary for us to take a close look at supply chain in the packaged food sector. Capturing creativity within supply chains has proved to be an effective way of delivering innovation for many mature industries such as the automotive industry (Delbridge and Mariotti 2009). Yet, studies within the packaged food sector suggest that it has yet to fully utilise its supply chain networks to increase NPD (van der Valk and Wynstra, 2005; Francis, 2009; Simms and Trott, 2014). Research within process industries, such as the food industry, has shown how important supply chain collaborations are to R&D and innovation (Cantista and Tylecote, 2008, Sahay, 2003, Soosay *et al.*, 2008; Santamaría et al., 2009 and Rodriguez-Pose, 2013). Indeed successful NPD often depends on companies' level of understanding and experience of operating in the chain-like structures (Tottie and Lager, 1995). Whilst firms have many potential partners (see Pittaway *et al.*, 2004), supplier-customer relationships have received particular attention within the literature (see Petersen *et al.*, 2003; Chung and Kim, 2002; Lambert, 2008; Wynstra *et al.*, 2010). For the supplier, developing a close relationship is critical to gaining the required inputs from customers into the development project (see Leifer 2000). Beyond this, the incorporation of suppliers into NPD allows a greater understanding of their needs (Freeman, 1982; Bruce and Rodgus, 1991). This can aid the development of new ideas (Biemans, 1991) and reduce risks (Gemunden *et al.*, 1992). Increasing levels of outsourcing (Fine, 1998; Wynstra *et al.*, 2010) has led to modularisation of products (Baldwin and Clark, 2000) as the product development becomes distributed across many firms. This has resulted in firms moving away from 'arms length' or transaction orientated purchasing relationships with suppliers towards more integrated relation-oriented ones (see Lambert, 2008; Wynstra *et al.*, 2010), where the communication is often handled by 'heavyweights' in the NPD team, who engage in significant external communication and vision setting, leading to more productive projects (Clark and Fujimoto, 1991). Prior research has however highlighted that the potential for the supplier to productively contribute to the customers' R&D is also dependent upon the customer maintaining internal capabilities, in order for the value of new technologies to be recognised internally (see absorptive capacity, Cohen and Levinthal,

1990; Brennan and Turnbull, 1999; Ford and McDowell, 1999; Ritter, 1999). Furthermore, “building and maintaining an external network of competencies is fundamental to keeping pace with leading edge technologies and knowledge and to exploiting business opportunities” (Chiesa et al., 2004, p. 72). Hence in order to achieve product innovation it has to be effectively combined with potential absorptive capacity, through the development of experience in mapping of the external knowledge (Zahra and George, 2002; Zhao and Calantone, 2003).

Cooperation within the supply chain is more common with ‘first tier’ suppliers (with which the customer has a direct purchasing and product input relationship), than with second and third-and-below (Takeishi and Fujimoto, 2001; Wynstra *et al.*, 2010). In our study, we would expect high levels of collaborative development to be evident with packaged food firms (see Fig. 2). Indeed, given the significance of suppliers such as ingredient and packaging suppliers to the activities of intermediaries and retailers we may also expect a willingness to cooperate at these other (further ‘downstream’) levels of the supply chain. However, prior studies have highlighted low levels of cooperation within the food and drink sectors (Stewart-Knox and Mitchell, 2003; Anderson and Wooley, 2002). Further, Lindgreen and Wynstra (2005) have suggested that this may be due to the current commodity nature of the packaged food sector’s offering, which may not fully reflect their technological and innovative capability. Hence, the customer’s willingness to collaborate may be dependent upon their view of the supplier’s potential contribution to the end product.

2.3 Technology adaptation: knowledge creation within manufacturing processes

New and commercially useful knowledge is not only the result of the conscious action of creative individuals; it is also the outcome of the interaction and learning processes among various actors in innovation systems, i.e. producers, users, suppliers, public authorities, and scientific institutions, which David and Foray (1995) have coined the “knowledge distribution power” of the innovation system. Within LMT sectors innovation generally involves the application of high-tech components into existing products and production processes (Robertson et al, 2009). Indeed, Kirner et al, (2009) found that low-tech firms perform as well as, and perhaps better than their high-tech counterparts at process innovation. The use of advanced manufacturing technology (AMT) (which captures the value of embodied technology), training and design are all of more importance in generating product and process innovation for LMT firms than for their high-tech counterparts (see Santamaría et al. (2009) study on Spanish manufacturing firms).

Within the manufacturing setting but a different LMT sector Chen (2009) showed how small and medium sized enterprises (SMEs) in the machine tool sector learn to adapt equipment for their specific requirements. Much of the activity is iterative trial-and-error to reduce uncertainty (Frishammar et al., 2013).

The packaged food industry like so many LMT sectors is dominated by large capital-intensive firms. Here productivity gains tend to be small but cumulative. Over time this can offer competitive advantage (Ghosal and Nair-Reichert, 2009). In the packaged food sector this takes place in the large food processing plants. This is where modular combinations of knowledge from different industries take place (Lundvall, 1992; Jensen et al 2007; Fitjar and Rodriguez-Pose, 2013). Significant innovation and value may be added at this stage. The introduction of any form of new product concept will require collaboration with the food processing factories. Significantly, due to the high integration of the food products and its packaging, it is packaging technology that provides many new product opportunities.

The roles played by LMT firms in adapting new technologies to fit existing technology frameworks forms a central part of this study.

2.4 Market entry: Retail buyers and Category Management

New products can create strains between manufacturers and supermarket retailers. Finding space on the shelf for new products affects one of the most fundamental strategic challenges facing food retailers: that is determining the product assortment to offer. The assortment composition will reflect choices in terms of quality, price and brand. This is referred to as product assortment planning (PAP). Retailers attempt to offer a balance among variety (number of categories), depth (number of lines within a category) and service level (the number of individual items). There are some clear constraints such as space and investment in stock. Within food retail there is a longstanding recognition of the importance of PAP; research mostly offers insights into subsets of the factors that affect this most challenging issue (see Mantrala et al., 2009). Within large food retailers the responsibility for PAP lies with Category Managers. Category Management⁴ is used by large food retailers as a way of breaking down the wide range of products purchased into discrete groups of similar or related products; these groups are known as product categories (examples of grocery categories might be: tinned fish or fresh fruit). Each category is often treated as a distinct business unit. It is the product listing decision process which many believe limits adoption of new products. Buyers are usually located at the retail organisation's head office and are classified by product category.

The introduction of category management imposed the condition that all actions undertaken, such as new products and in-store promotions were beneficial to the retailer and the end consumer. Category management shifts the focus of all supplier negotiations to the effect on turnover of the category as whole, not just the sales of individual products or brands. For example, promotion of one brand may simply lead to a fall in sales of the competitor brand resulting in no overall increase in revenue to the retailer. This effectively raises the bar for any new product innovation as it must not only take sales from competitors, but also it has to increase total sales of the category. Effective collaboration with suppliers enables retailers to outsource a considerable amount of workload in developing a category. Indeed frequently a particular supplier in a category is nominated by the retailer as a category leader (or captain). The category captain will be expected to have the closest contact with the retailer and will also be expected to invest time, effort, and often financial assets into the strategic development of the category within the retailer (Lindbloom et al., 2009).

Any new food product has to be accepted by a retailer to make it onto a shelf. Yet given the PAP challenge faced by Category Managers it is not surprising that innovators and entrepreneurs with new ideas feel retailers do not want their new products. The decision making process of Category Managers determines whether new products are made available to end-users. According to Mantrala et al., (2009) Category Managers have an intuitive feel for their assortment decisions. Arguably additional decision support models may help them make more rational and empirically informed decisions and so demystify the black art of category management. Empirical studies of product success and failure within the food and drinks sectors have revealed notable product failure rates (Stewart-Knox and Mitchell, 2003; Fuller, 2004) and restricted chances of new product success, which are costly to the industry (Morris, 1993).

Users of products have consistently provided producers with valuable knowledge. The theory that users contribute to the innovation process has become established within the mainstream innovation management literature. Eric von Hippel's work in this area forms a significant part of the theoretical underpinning and evidence behind this concept. In their review of users as innovators Bogers et al. (2010, p.859) explain that 'intermediate users are firms that use equipment and components from producers to produce goods and services' whereas 'consumer users – users of consumer goods – are typically individual end consumers'. Interactions with

⁴ Category Management is a collaborative continuous process between manufacturers and retailers to manage a group of products which is referred to as a 'category'. The purpose of this process is to optimise shopper satisfaction and fulfil the role chosen by the retailer for that category (Mantrala et al., 2009).

users provide opportunities to trial product concepts and co-creation. von Hippel (2005) has provided a range of examples of how certain users can take on a role as designers to interact with product developers in companies. Since lead users are familiar with conditions that lie in the future for most others, they can serve as a need-forecasting laboratory for market research. In the packaged food sector market acceptance is determined by the retail buyers and category managers.

2.5 Development of propositions

The above discussions on Doing, Using and Interacting (DUI) modes of innovation and low and medium technology (LMT) industries provide an opportunity to combine these two constructs and develop a group of organisational characteristics grouped into the key features found in the existing literature. Clearly additional research is required to throw further light on how DUI effects product and process innovation and the effects of different configurations of DUI practices. This needs to examine both intra-firm and inter-firm processes. It is the nature of these activities specifically regarding how human interactions help combine different knowledge sets that will illustrate innovation in action. Primarily, it is our suggestion that within LMT industries DUI modes of innovation rely heavily on middle managers in the form of project leaders as agents of change. This is because 'learning-by-doing, by-using, and by interacting' is embedded in the daily routines of manufacturing tasks. Problems and solutions are uncovered through trial and error within the pressurised atmosphere of a production-line (Frishammar et al., 2013).

The unique characteristics of the packaged food industry (category management and PAP) in general and the packaged food supply chain in particular contribute to our theoretical framework and propositions. We build our conceptual framework on a cornerstone of the DUI mode of innovation that is interaction amongst the supply chain. We identify three key players within the innovation supply chain and position them at the front end: suppliers and specialist suppliers; food processing and retail. We also identify the influential role played by category management in the packaged food sector. Figure 1 links together the packaged food supply chain and our propositions.

The above discussion of theory has examined how the packaged food supply chain uses DUI to deliver product innovation. While there is evidence to support the notion of DUI mode there are few detailed studies of individual sectors, hence researchers have been unable to verify the data beyond the **general** level (Robertson et al., 2009). That is, previous studies have been based on large-scale cross-section studies. We offer detailed insight into the processes of DUI. Our propositions explore the effects in practice of incremental product and process innovations amongst the supply chain, the nature of iterative trial-and-error product development and the influence of category management on the innovation process.

For the benefit of the reader and to provide a summary of our literature review we have grouped together eight general characteristics of functioning modes of industrial DUI in low and medium technology sectors (see Table 2). We link this to evidence from research within the wider innovation literature. This provides some guidance on specific knowledge creation features that we are likely to uncover. This helps us develop our five specific propositions for our study of DUI within the packaged food sector.

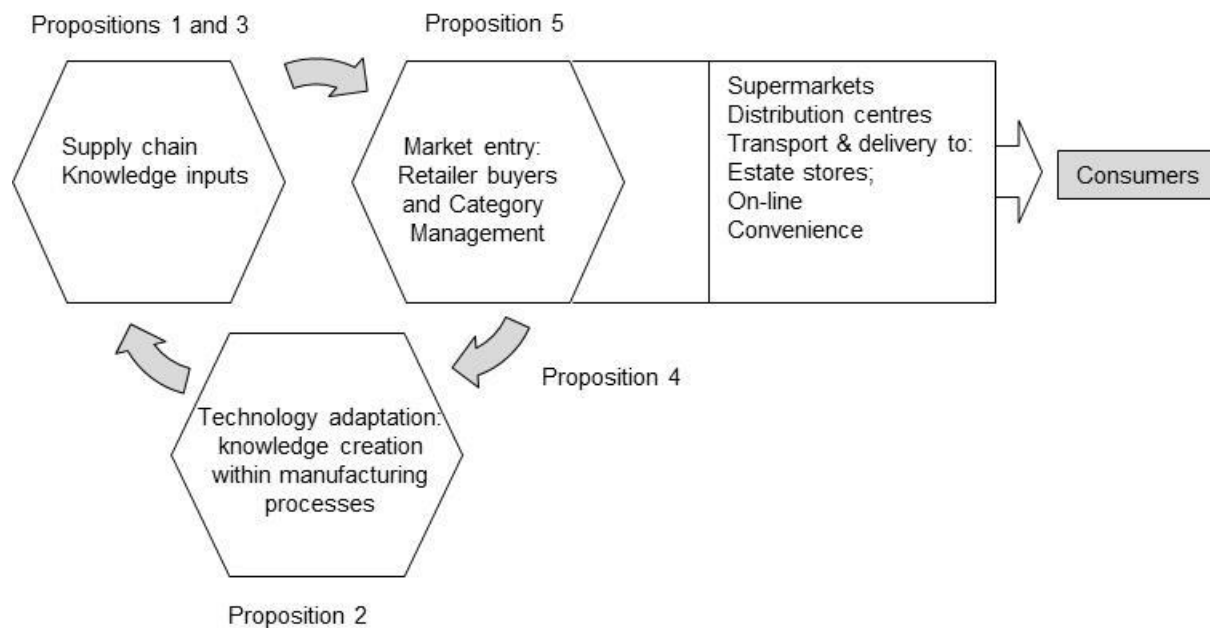
Table 2: A theoretical synthesis of DUI modes of innovation and low technology sectors for packaged food sector

	General characteristics of functioning modes of industrial DUI in LMT industries	Evidenced from the wider innovation literature	Specific knowledge creation characteristics	Propositions for packaged food sector
1.	Regional and national knowledge network linkages	<p>Audretsch and Stephan (1996)</p> <p>Feldman and Audretsch (1999)</p> <p>Asheim and Gertler (2005)</p> <p>Corrocher, et al.,(2009).</p> <p>Asheim and Coenen (2005)</p> <p>Fitjar and Rodriguez-Pose (2013)</p> <p>Schmitz (1985)</p> <p>Guiliani and Bell (2009)</p> <p>Kuhne et al., (2015); Menrad (2004)</p>	<p>Proximity of firm-scientist network</p> <p>Diversity / specialization of economic activity promotes technological change</p> <p>Geography of innovation</p> <p>Cluster membership within knowledge-intensive business services (KIBS)</p> <p>Regional innovation systems</p> <p>Interaction-based innovation</p> <p>Clusters of specialised firms</p> <p>Evidence of clusters within the wine industry</p> <p>Collaborative ‘food provision system’</p>	1. Firms in the packaged food sector will operate a DUI mode of innovation, with emphasis on incremental product and process innovations amongst the supply chain.
2.	Firms interact and share experiences and practice;	<p>Fitjar and Rodriguez-Pose, (2013)</p> <p>Tottie and Lager (1995)</p> <p>Filippaios et al. (2009); von Tunzelmann and Acha (2005)</p> <p>Menrad (2004)</p>	<p>Collaboration and firm interaction within the supply-chain</p> <p>Experience of operating in the ‘chain-like’ structures within process industries</p> <p>Food innovation requiring the integration of diverse types of technical capabilities</p> <p>Role of ‘Interfacing competencies’ for collaborative innovation in food firms</p>	
3.	Innovation within LMT industries is supplier dominated’ and is driven by purchases of embodied technology.	<p>Pavitt (1984)</p> <p>Chung and Kim (2002)</p> <p>Bunduchi and Smart, 2010;</p> <p>Patist and Bates (2008); Ettlie (1983); Simms and Trott (2014)</p>	<p>Supplier dominated firms drive innovation</p> <p>Partnership between manufacturers and suppliers for NPD</p> <p>Process Innovation Costs in Supply Networks</p> <p>Influence of capital investments on innovation decision-making within the food and food packaging sectors</p>	2. Firms in the packaged food sector will rely on iterative trial-and-error to adapt technology to their own needs
4.	Extensive on-the-job problem solving occurs; especially at the manufacturing-R&D interface.	<p>Lundvall and Johnson (1994); Lundvall (2010); Nonaka (1995)</p> <p>Frishammar et al., 2013;</p> <p><i>Santamaría et al., (2009</i></p> <p>Jensen et al (2007);</p> <p>Aylen, (2013)</p> <p>Parilli and Heras (2016)</p>	<p>Interactive learning</p> <p>Creation of process definitions through iterative trial-and-error processes</p> <p>Non formal R&D processes in LMT industries</p> <p>Extensive on-the-job problem solving occurs</p> <p>Intensity of use leads to evolutionary learning</p> <p>Learning- by-doing, by-using, and by-interacting (DUI)</p>	

	General characteristics of functioning modes of industrial DUI in LMT industries	Evidenced from the wider innovation literature	Specific knowledge creation characteristics	Propositions for packaged food sector
5.	High levels of tacit knowledge and the use of organisational memory (in process industry changes in the plant set up will deliver new products).	Fitjar and Rodriguez-Pose (2013); Nonaka and Hirotaka (1995) Maskell and Malmberg (1999) Anderson and Woolley, 2002; van der Valk and Wynstra, 2005 Aylen (2013) Rao et al., (2006) von Hippel, 2005; Lambert, 2008	Tacit knowledge and learning by doing Creation of knowledge faster than competitors Increasing significant role for purchasing and supply management 'Line stretch' as a mechanism through which established plants incorporate new technologies to generate new products within process industries. Retailer category manager interface for agribusinesses Intensity of user/supplier relationship can lead to product innovation	3. The DUI mode of innovation within the packaged foods sector requires extensive networking activities in order to provide the diverse skills required to develop new knowledge.
6.	Continuous optimisation of processes and of the existing technologies	Benner and Tushman, 2003; Levinthal and March, 1993; Chu et al., (2009) Cowling (2003) Filippaios et al. (2009)	Adaptive behaviour in buyer–supplier relationships Firms sustain exploration and a tendency to overinvest in exploitation. The joint effect of project-level exploratory and exploitative learning Evidence of continuous learning throughout the life of plant within process industries Product adaptation is a key technological activity within the food industry	4. The anticipated costs associated with the adoption of new technologies will lead to an emphasis on incremental innovations to meet the existing customers' needs.
7.	Dominance of incremental, mostly process driven innovations	Cohendet and Llerena, 2010; Malerba (2010) Aylen (2013) Parrilli and Herras (2016) Archibugi, Cesarrato, and Sirilli (1991) Menrad (2004)	Sources of creativity in innovative company that does not rely on traditional sources of innovation Continuous optimisation of processes and of the existing technologies Intensity of use leads to learning benefits 'Non-technological innovation' greatest impact of DUI mode of interaction Process-innovation orientation identified within food firms Evidence of high numbers of modified food products combined with process innovations	
8.	Intensive user- producer interaction (this is often not the end consumer)	Mantrala et al., (2009) Lager and Frishimmar (2012) Costa and Jongen (2006) Grunert et al. (2005)	Category Management is central to the innovation adoption model Involvement of 'early users' in process technology development within process industries Consumer-led development as an NPD strategy for food firms User-led food development incorporating not just end consumers, but also retailers	5. Category Management plays a key role in the level of innovation between the retailer and other supply chain members. The preferred supplier relationship with the category manager determines the nature of innovation.

Figure 1: Conceptual framework for low tech innovation within the packaged food sector supply chain

Figure 1: Conceptual framework for low tech innovation within the packaged food sector



3. Research methodology

The role of low technology intensive firms and industries in modern economies is frequently misunderstood and yet they are essential parts of the system that underpins the success of large innovative firms (Robertson, 2003; Robertson and Patel, 2007). Hirsch-Kreinsen et al. (2005a,b) and von Tunzelmann and Acha (2005) criticise the lack of scholarly attention to low- and medium-technology industries in current innovation research and policies. This partly explains the decision by Research Policy to devote a special issue to the subject in 2009. This was a significant contribution to the field, but raised additional questions and called for specific 'detailed studies of individual sectors to help to sort out the effects in practice', (Robertson et al., 2009: 446). In particular the editors called for more detailed studies that approach innovation from diverse angles rather than a reliance on existing data that leads to issues being framed in

less than adequate ways for reasons of convenience for researchers. This helped direct our rationale for case study research.

Case-based exploratory methods are best suited for investigating new and poorly understood phenomena (Eisenhardt, 1989) that have multiple and complex elements (Dodgson et al., 2008) and that evolve over time (Langley, 1989). Since product innovation is a multi-faceted phenomenon and DUI a relatively new concept, an analysis of multiple case studies over time would provide a good understanding of the drivers, dynamics and consequences of DUI mode of innovation in the packaged food sector. We have selected four live cases that are incomplete. Either they are on-going and development work continues or they have been postponed until a suitable partner emerges. The rationale for this was to avoid a major concern of case writing that of the retrospective method. There is an increase risk of biases and errors being introduced when the evidence relies on substantial data from the use of retrospective reports (Runyan, 1982).

Our fieldwork began in 2009 and entailed a preliminary investigation of key informants, relevant policy documents and websites describing innovation and NPD in the packaged food sector. This has evolved into a long-term research project that is supported by a range of businesses from the packaged food sector including: Crown Packaging; Co-op Foods; Chesapeake Packaging; and Kern. Four separate three year research projects have been established. These are exploring different aspects of NPD within the packaged food sector. This particular research project is independent and has not been funded from any of the above. The choice of research subject arose from discussions amongst the authors alone.

Collaborative research is considered a good means to study and model managerial practices and issues (i.e., Shani et al., 2007). This paper presents the results of four separate case studies from the collaboration with firms from the packaged food industry who have sponsored the research projects. The researchers were invited to the organisations to study a problem that was identified as being relevant and critical to both practitioners and researchers (Starkey and Madan, 2001; Hatchuel, 2001). During this three-year period, 54 packaging R&D projects (historical and current) have been examined, covering most of the company's significant clients, and a detailed database of projects has been assembled. It is from this population that we have selected four cases. One illustrates product innovation led by a retailer, another shows product innovation led by an international packaged food brand and the two other cases provide insight to innovations driven by different specialist equipment suppliers. These cases offer variations along our analytical constructs of supply chain knowledge inputs; technology adaption, and market entry (Flyvberg, 2001), a feature likely to increase the theoretical relevance of our observations (Eisenhardt, 1989; Gibbert and Ruigrok, 2010). Cases that were both 'critical' to the organization and 'illustrative' of the issues it experienced were selected (e.g. Patton, 2002). The cases were also selected for their 'intrinsic value' (Stake, 1995). Whilst the authors are aware of the perceived limits on such a research design, we believed it was well suited to generating new and valid insights in the early stages of theory development and in providing analytical generalisation in relation to theory (Eisenhardt, 1989; Eisenhardt & Graebner, 2007).

Multiple sources of data were used in accordance with principles of "triangulation" (Yin, 1994; Flick, 1998; Eisenhardt, 1989) in order to minimise subjectivity, which included interviews and observations over the three-year period, attendance at R&D meetings, and meetings with key suppliers and customers. Data were also gathered from internal presentations and documentation, as well as email communications. With respect to the interview study, the paper draws upon information gathered from key members of the organisation, as well as interviews

with other key supply chain partners relevant to the R&D projects and process (summarised in Table 3). Table 7 (Appendix 1) shows details of all the interviews and participants. The case study followed the procedures set out by Yin (2009). Set questions were developed for the interviews, although departures from this structure were permitted in the interest of exploring new and potentially fruitful points (Appendix 2). Some adaption in the format of discussions was allowed from one discussion to the next to pursue interesting and particularly relevant new facets of the case study as they emerged (Nag et al., 2007). The cross case comparisons used numerous tables searching for patterns, selecting categories and looking for similarities and differences. Finally we systematically compared the emergent patterns with the evidence from each case in order to assess how well or how poorly these fit with case data. A close fit between the theory and data takes advantage of potentially new insights that emerge from the data and leads to empirically valid theory (Miles and Huberman, 1994).

Table 3: Cases and technology change

	Company and NPD Project	Technical change	Respondent	Supply chain partner	Respondent
1	UK Food supermarket New Fish product	Introduction of new packaging format	Category Manager; Packaging Innovation Manager; Marketing Manager.	Packaging Supplier	Project Manager Technical Director
2	Packaging company Formable board	Introduction of new paper board that can stretch' by between 5-10%.	R&D Director; Production Manager Marketing Manager	Paper/board supplier	R&D Manager
3	Packaging Company Milk pouch	new lightweight aseptic packaging system for liquid food products	R&D Director; Project Manager.	UK Food supermarket	Packaging Buyer Category Manager
				Dairy processing factory	Production Manager
				Brand owner Goats milk	Marketing Manager
4	Food Producer Chocolate bar	Introduction of cold extrusion production technology	R&D Director; New Product Team Leader; Product Packaging Team Leader; Marketing Manager.	UK Food supermarket	Category Manager

4. Findings: case studies

We present our findings in two parts: (i) a brief description of the four cases; (ii) an analysis of the cases against the STI mode (Table 4); (iii) a cross case analysis structured around our five propositions. Table 5 shows the supporting evidence from each case.

4.1 Food retailer: Development of a new packaging format

One of the UK's most successful food retailer's began development work in 2008 on a new type of packaging for fish. The project was initiated following retail Category Team's analysis of some consumer research findings which identified factors they disliked when preparing and cooking fish. These were seen to preclude some people from eating fish as often as they might otherwise choose. The marketing team worked alongside the packaging team, to conduct consumer focus groups at the company's headquarters. This revealed the following issues:-

1. Consumers do not like preparing fish because the smell seems to remain on their hands;
2. Consumers do not like cooking fish because of the smell left in the kitchen;
3. It may be possible to cook fish better if it is contained inside a form of pack that aids the cooking process, creating a better end result.

A project was initiated to generate a pack in which fish could be cooked that would avoid consumers having to directly touch the fish, stop the smell infiltrating the kitchen, and help to steam the fish. The packaging team approached its fish and packaging suppliers, with the product brief. Four suppliers presented proposed prototypes. One supplier presented a pouch made from a plastic and metal foil, which had been adapted from one of its existing packaging designs used for meat. The prototype presented to the retailer's team had been *"produced on our existing line with variations in the materials used and its shape"* [RA2]. This was further developed through a number of tests and production line trials, until the desired end result was achieved.

Having established a working prototype, the packaging team went back to the NPD team to propose initiating consumer trials. However, the Category Manager was reluctant to take the project further. He was *"concerned about both the increased costs of the format, and the investments required"* [RA8]. The Packaging Innovation Manager believed the Category Manager *"was too risk averse to adopt the new packaging format... particularly as it was unusual and more radical"* [RA2]. This view was shared by RA7 and RA1, for example RA1 stated: *"I was onboard with this project and could see significant potential in the market, but the [category] manager seemed to focus largely on the risk of failure, and it was hard to get him to look beyond this"*. Ultimately, there was concern that these investments would have little impact on growth and additional sales for the whole category. Indeed, in the current financial climate; *"cost is a big factor, therefore new formats are not considered heavily"* [RA8]. The project was thereby suspended.

Over the year that followed, the Packaging Innovation Manager continued to discuss the proposal Category Manager, but he was unwilling to fund additional consumer testing it. It was noted that it was *"hard to get Categories to adopt new packaging formats"* [RA2], and managers were under *"pressure to focus on the day-to-day running, which leads to a lack of consideration of the possible returns from a more long-term view"* on developments; indeed, *"the Category Manager's perspective, as a buyer, tends to compound this problem"* [RA2].

Approximately twelve months after the Category Manager's initial rejection, the packaging supplier requested termination of the contract so that they could explore other potential customers for the new packaging format. It was agreed that sufficient time had been given to take up this format, and so the supplier was given approval to approach other firms. The Packaging Innovation Manager noted, *"sometimes I can't get Category Managers interested enough, so it's left for someone else to pick it up"* [RA2]. Subsequently, the format was taken up by one of the world's largest Consumer Food groups and launched across Europe using their frozen food brand. It has become considerable success with sales in excess of £10 million. Significantly other food producers are now introducing the product format into their ranges.

4.2 Food packaging producer: Formable Board

Formable board, is a joint development project between UK paperboard manufacturer Chesapeake and a Swedish paper and board materials supplier. The Swedish board supplier approached Chesapeake with a newly developed and patented (solid bleach sulphate) board material with the unique quality of being able to 'stretch' by between 5-10%. That is, it could be formed into shapes or embossed effects. This differentiated it from other board packaging which could only be cut, folded, creased, or curved. Hence the technology was considered to be *"one of the most significant packaging innovations in the history of the paperboard packaging industry"* [PC2]. This could provide Chesapeake with new opportunities to compete with more flexible materials (particularly plastics), and enable board to be utilised in new product applications. It also had other clear benefits such as its recycling appeal.

While substantial material development had already been undertaken by the board supplier, it was not yet 'production ready'. The supplier needed a manufacturing partner to implement the board into a production line, develop an appropriate manufacturing process for different applications, and make it commercially viable. For Chesapeake this was a project with large upfront costs. As a result, the Head of R&D [PC2] initially wanted to *"establish an exclusive contract"* of sole supply, to ensure payback from the investments. The board supplier initially rejected the proposal. In early 2011 an agreement was reached on the development work undertaken, mitigating the risk of these investments. Chesapeake approached a number of existing and potential customers, but struggled to verify the best current, and possible future, target markets and applications for the technology. Unfortunately, customers were focused on identifying lowest cost for their existing products and were not interested in new products. In some cases Chesapeake was able to communicate with packaging technologists but, whilst they recognised potential benefits in the technology, these technologists had little influence in decision-making. This was summarized by the R&D Manager: "[packaging] *technologists are more detached from the development team*" and *"basically its buyers... visit a number of 'kit' manufacturers to choose the best one [equipment]"*.

Early in the project several technical challenges were identified. Tests on the production line identified that, when making large formed shapes, the 'male' and 'female' plates used to form materials on most existing equipment would *"bend before enough pressure had been applied to form the board"* [PC8]. On the other hand *"smaller shapes, such as blister packs for pills, could be made using existing tooling, thereby lowering switching costs"* [PC2]. Whilst this was seen as a potential advantage, Chesapeake was unable to establish the potential for the technology in this sector. Initially, the team wanted to identify a lead user or target sector for the adoption of the technology. This would allow them to target their investment at a particular application *"in order to get the technology established and get returns on the investments"* [PC2].

The development team wished to show the full potential of the technology and to illustrate the potential applications of the technology. Potential customers showed no interest. They argued that their customer (the food retailer) 'wanted lower costs not additional costs'. Without detailed and specific customer insights it was possible to make only a few general prototypes to show to prospective client firms (in order to keep costs low), which was *"not the optimal way of demonstrating the product"* [PC7] for the sales staff.

The new product team were frustrated that potential customers were solely focused on lowest cost. Indeed, the behaviour is reinforced by buying practices. Customers *"are unkeen (sic) to make changes, as it will put up the costs of the materials which can lower their bonuses.... even small cost increases are avoided... The buyer interface is a big issue.... It is difficult to speak to others for whom new packaging could potentially add value..... In some cases if we try to communicate with others within the firm we risk losing the contract, as the buyers get bonuses for buying packaging cheaply and therefore they do not want their colleagues to be pushing for more expensive packaging"* [PC7].

Frustration set in and without expressions of interest from potential customers it became difficult to build a business case for the technology internally. On two occasions the project was suspended due to a lack of market demand. After two years of failing to identify a customer, the company is now in the final stages of negotiation with a branded customer.

4.3 Dairy Innovation Project: Milk Pouch

This project concerned the development of a new type of packaging for milk and milk alternatives. Plastic bags, as a format for packaging milk, had been used since the 1960's, but they had proven unpopular with consumers. In 2010 some commercial national restaurant chains had begun requesting this type of product. The packaging company offered to supply one UK supermarket with milk in bags as they minimised packaging, with obvious environmental and cost benefits. The project team at the packaging company also linked this renewed interest in the format with an overall increase in the use of 'pouches' (including retort pouches) within the FMCG sector.

The development team's early analysis highlighted that a milk bag's lack of ability to 'stand up', meant that it was necessary for consumers to put them into a jug for opening, storage and use. For retailers this also affected the display of the product on their shelves, and the format was seen to have a look of "poor quality" [PC18]. The team focused on developing an alternative that would cut costs and material usage, whilst retaining some rigidity in order to be freestanding. The team began developing a milk bag with a *"built in 'spine' that will support the bag and provide rigidity"* [PC8]. This would keep weight and waste lower than a plastic bottle or carton but would be more convenient than the existing bags.

The existing format of packaging used by firms was typically cartons or Polythene bottles. Any process change was viewed in terms of additional costs rather than an opportunity to add value and increase margins. For example, the spine for the bag could be made from a number of different materials, or with the rigidity coming from the polymeric formulation. The team eventually chose to focus on a new polymeric formulation technology that would change properties depending on the temperature in which it was stored. Thus, the bag would be able to provide rigidity when cool, and hence whilst it stored the milk. But, it would lose rigidity in ambient temperatures, allowing it to be compacted during the remainder of its lifecycle and through disposal. The packaging R&D team began to explore possible structures and materials, (using existing polymer material suppliers). One supplier offered a suitable material that had been developed for another customer. The packaging team also attempted to establish the likely demand, potential customers, and specific customer development requirements. The team identified three types of potential clients: supermarkets (own brand milk), smaller independent dairies producing branded premium milk, and suppliers of milk related products.

The majority of milk sold within the UK was (supermarket) own brand, hence Chesapeake considered this the primary target market. Category Managers from all the UK's major supermarkets had *"no interest in the new technology as their primary focus is on cost reduction of existing formats. We tried to emphasise the other benefits . . . [but it was hard to] communicate the technology to other members of staff in the client firm"* [PC2].

Meetings were also held with packaging technologists, but despite positive feedback, they lacked the ability to actually implement the packaging into products, as decisions were down to Category, Product, or Brand managers. A meeting with a key FMCG client illustrated some of these issues. PC19 took interest in the product, however he noted *"I don't have any say in the decisions"*, similarly PC20 stated *"I don't have the decision making power"*.

Category managers were identified as *"key decision makers, initiating most large changes within each category"* [P19]. However, the outsourced nature of production for own brand products resulted in the majority of packaging decisions being made by the (dairy) supplier's packaging team. The supplier's responsibility for packaging decision making is influenced by their existing equipment and production activities with costs, driving decision-making. For example, Dairies *"resist change due to the high costs involved and particularly as they operate*

on low margins or at a loss” [P7]. The use of bags as opposed to polythene bottle also presented some advantages to the dairy processing factories. Empty light weight polythene four pint containers are notoriously difficult to handle. The idea of producing bags of milk appealed to the dairies: *“it would be much easier for us to produce a polythene sausage of milk which we then clamp and seal in four pint sections”* [PC14].

The packaging supplier recognised that this project required the backing of the supermarket. But the supermarket’s position according to the Category Manager was: *“the packaging specification is part of the supplier’s role”* [PC18]. The supplier was understandably reluctant to invest in production process technologies, especially when their main customer was not seeking any change. The team therefore faced the challenge of having to convince both the Dairy Processing Plant to invest in new plant and the Retailer that a change in format to milk pouches. Both were unconvinced. In particular the retailer felt that *“consumers were happy with polythene containers’ if others change then we would consider changing too”* [PC18].

More interest in the new format was found at small specialist dairies producing branded premium milk and suppliers of milk related products (e.g. low lactose, soya, or goats milk). The brand owners of these products controlled the packaging themselves. Nonetheless they were also concerned about the risks of adopting the new bag-based technology. For example, the Goats Milk Brand Development Manager said the bag may not *“add the required value for higher quality perceptions, in order for our premium to be achieved when compared to their existing carton packaging”* [PC19].

4.4 Food Producer: Applying new production technology for a chocolate bar

Production technology development in another food business unit (BU) provided an opportunity for the firm to use it on a confectionery product. The new technology could be applied to wafer based chocolate bars. The new production technology used a unique form of extrusion process to remove the need to join layers of biscuit within a bar by heating, which was the traditional method of forming a biscuit based chocolate bar. Hence it delivered *“a faster process by minimising the drying time between cooking the biscuit and coating. This improved production speed and lowered costs”* [BC15]. The only disadvantage was that it affected the product’s visual appearance, and produced a harder more brittle bar. The aim of the project was to apply the technology to develop a new brand. A brief was developed within the new product team (NPT) the standard product brief outlined:- Products and product lines; technologies; recipes and ingredients; points of differentiation; shapes of the product; launch date. Together, this defined the physical product and helped to ensure commitment from key decision makers. The project leader stated: *“for these types of products flowwrap is really the only option, development is focused on creating graphics for the wrap”* [BC15]. The firm uses *“this type of packaging on similar products, the product could therefore run on a similar production and packaging line... retails can also display it alongside our existing products... cutting investments and risk”* [BC15]. The product technology centre (PTC) examined machinery and manufacturing, investments, and technical development. From this, the team developed the final business case and secured internal investment.

At the concept development stage production equipment was to be purchased, the factory built up, feasibility established, and test runs made on the production line. Engineering and quality teams ensured safety and quality control. Concurrently, a design firm was recruited to work on a design for the surface of the packaging. The chosen design would then be outsourced to a packaging supplier to produce the flow wrap. When the internal Product Packaging Team (PPT) began to verify and develop specifications for the flow wrap they highlighted two problems:

1. Due to the product's brittle nature, the packaging would not provide adequate protection on the production line, thus it would be prone to breaking.
2. Inadequate protection would also result in it getting broken easily when packing into tertiary packaging for distribution.

The Marketing Manager explained: *"I have discussed this with a few category managers. We have to be careful here, we risk damaging our relationship with the retailers as they expect us to unconditionally guarantee the products. We have to accept all returns, no matter the reason".*

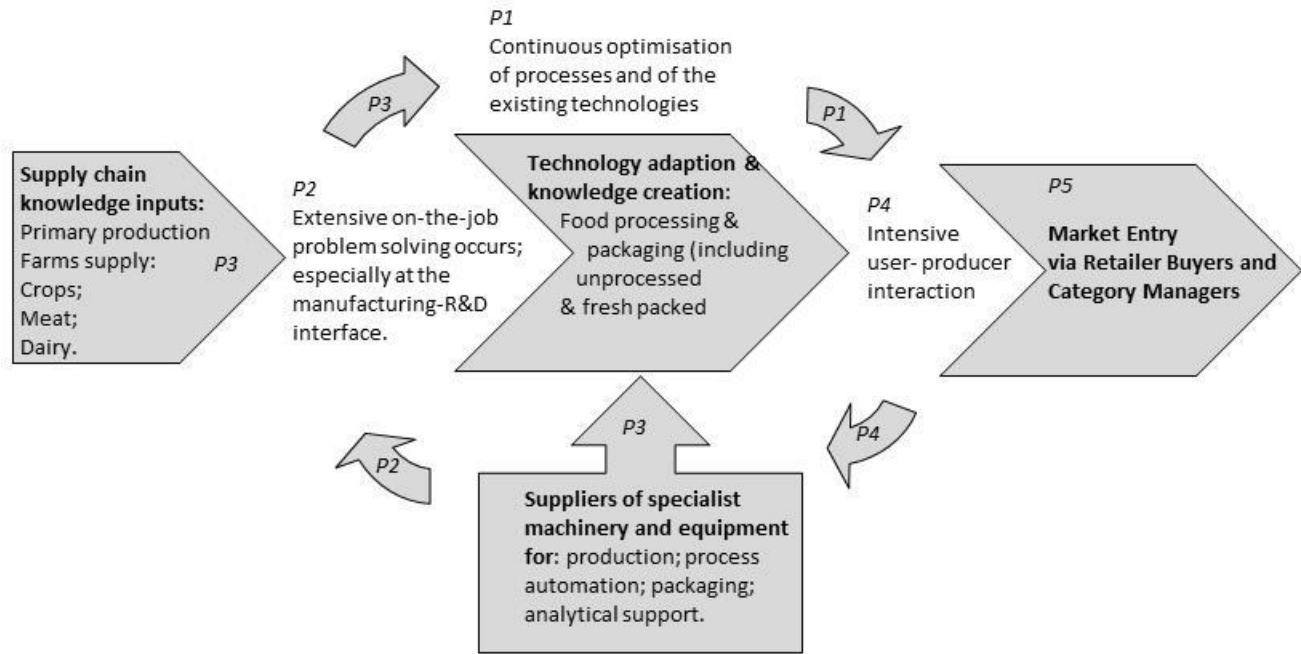
By making adjustments and experimenting with the line the team discovered that by running the line at slower speeds they were able to reduce breakages. *"We simply tried different things, the shop floor engineers had lots of ideas"* [BC15]. However, this negated much of the advantage of the new faster production technology. The team experimented with producing larger flow wraps and inserting the board by hand on the production line, but each of these solutions would have added costs to the packaging. The R&D Director revealed: *"The lack of a holistic approach to product and packaging development caused the problems..... [the] packaging was initially given minimal consideration at the stage of the project brief"* [BC14]. The problem originated from *"not having packaging staff, involved in the project from the beginning resulted in the format being selected based on basic misunderstanding and limited experience"* [BC15]. At the time of writing up this case study the project had not made it to launch.

5. Cross case analysis of propositions

Table 5 shows our propositions and supporting evidence from the case studies. It also shows how each proposition contributes to particular literature. The following section discusses and summarises this analysis for the five propositions. Figure 2 draws together our findings in an enhanced conceptual framework. It illustrates the effects in practice of activities such as learning by doing, on the job problem solving and the use of external firm sources on the process of innovation.

[insert Figure 2 here]

Figure 2: The DUI mode of innovation in the packaged food sector



5.1 Emphasis on incremental product and process innovations within the current technological trajectory.

In our analysis our case studies show how firms rely on key suppliers to help them solve problems. In the milk pouch case the packaging firm worked with printers to develop a new polymeric formulation technology that would change properties depending on the temperature in which it was stored. The case of a new packaging format for fish illustrated the use of more formal techniques for incremental innovation and problem solution through the use of a product brief. This led to detailed subsequent discussions with advanced packaging suppliers. The co-extrusion chocolate bar case showed how technology knowledge and expertise within another business unit was shared and applied to the confectionary business.

Evidence of the influence of older technologies and older knowledge is provided in our cases and Tables 5.1-5.5. These technologies clearly provide vital building blocks for the discoveries of highly innovative firms.

The specific evidence for the propositions is laid out in Table 5.1.

Table 5.1: Proposition 1 and supporting evidence from case studies

	Propositions	Identified in cases	Evidence of doing, using interacting mode of innovation	Contribution to literature
		Case 1: Fish	"we [the retailer's packaging team] approached a total of six of our approved fish and packaging suppliers with a brief to develop a pack that fish would be cooked inside." [RC3]	Support for this proposition will

1.	Firms in the packaged food sector will operate a DUI mode of innovation, with emphasis on incremental product and process innovations within the current technological trajectory.	Case 1: Fish	"We ourselves undertook little development, as we lack the internal capabilities and facilities to develop new packaging technologies..... [as retailers] we rely heavily on our suppliers to undertake technical development" [RC3]	contribute to the specific studies of Menrad (2004) and Fitjar and Rodriguez-Pose (2013).
		Case 2: Board	"We were approached by a board supplier, who had a newly developed and patented (solid bleach sulphate) board material" [PC2]	
		Case 2: Board	"While substantial material development had already been undertaken by the board supplier, they lacked the ability to implement the board into a production line, develop an appropriate manufacturing process for different applications and make it commercially viable." [PC2]	
		Case 3: Pouch	"our relationships with our existing materials and printing suppliers were key to the new innovation, we are not printing specialists" [PC6]	
		Case 3: Pouch	"we worked extensively with our printers to develop a new polymeric formulation technology that would change properties depending on the temperature in which it was stored" [PC8].	
		Case 4: Chocolate	"Having identified the problem, the team got in touch with a number of existing suppliers and network contacts to look for potential solutions". [BC14]	
		Case 4: Chocolate	"One of our suppliers took great interest, and we worked closely with them to develop this new solution" [BC18]	

5.2 Iterative trial-and-error to adapt technology to their own needs

The chocolate bar extrusion case shows how the machine tool supplier experimented on the production line by varying production speeds, and experimenting with added layers of material to protect the bar. The formable paper board case also showed trial and error activities on the shop floor as the tooling would break at certain loadings but not others. Thus we find support for Proposition 2 that the innovation activities of the firms in our cases we analysed rely on iterative trial-and-error to adapt technology to their own needs. The cases provide evidence of new technologies being used in the packaged food sector that have been developed in other industries and are driven by purchases of embodied technology. These improvised changes show considerable creativity which led to the development of new knowledge. This confirms previous findings including Patel and Pavitt (1994) and Pavitt's 1984 conclusions. The specific evidence for the propositions is laid out in Table 5.2.

Table 5.2: Proposition 2 and supporting evidence from case studies

	Propositions	Identified in cases	Evidence of doing, using interacting mode of innovation	Contribution to literature
2.	Firms rely on iterative trial-and-error to adapt technology to their own needs	Case 1: Fish	"Following the identification of the new opportunity, our suppliers worked to develop a number of prototypes which were tested on their existing lines for other similar meat packs" [RC4]	Support for this proposition will contribute to the specific studies of Jensen et al (2007); Lundvall (2010); Frishammar et al., (2013).
		Case 1: Fish	"We trialled a number of different materials for the bottom and top of the new bag format, before settling on the final solution "[RC5].	
		Case 2: Board	"Early in the project, different technical challenges were identified. Our tests found that, when making large formed shapes, the 'male' and 'female' plates used to form materials on most existing equipment would bend before enough pressure had been applied to form the board" [PC2].	
		Case 2: Board	"We used existing production machinery to test the formable board, as well as equipment for other materials" [PC1]	

	Case 3: Pouch	"the new pack went through testing at our kitchens, and after a number of minor iterations a working prototype with the desired qualities was finalized" [PC15]
	Case 3: Pouch	"We experienced problems with getting the pack to 'stand up' on its own, and maintain sufficient rigidity, therefore we experimented with a range of materials, inks and other potential solutions to try to solve the problem" [PC8]
	Case 4: Chocolate	"Having identified the new technology, the core development team experimented with a range of different types of biscuit based fillings, and various chocolate coatings" [BC18].
	Case 4: Chocolate	"Having identified the problem with bars breaking apart on the line we spent a great deal of time varying production speeds, experimenting with added layers of material to protect the bar...." [BC15]

5.3 The DUI mode of innovation within the packaged food sector requires extensive networking activities in order to provide the diverse skills required to develop new knowledge.

The formable paper board case illustrates the development and production of new designs previously not possible. This was achieved using existing production processes and adapting them to process the new material. The outcome was packaging board with unique properties. Even though inputs of new knowledge flow more commonly from sectors classified as high-tech. Similarly the milk pouch case illustrates supply chain knowledge inputs, this time from existing polymer material suppliers who was able to identify a suitable material that had been developed for another customer. A close working relationship between material supplier and packaging producer enabled the material to be adapted to deliver the customised product. This confirms previous studies showing how the incorporation of suppliers into NPD allows a greater understanding of their needs (Freeman, 1982; Bruce and Rodgus, 1991).

It was interactions and networking with customers in the form of retailers which delivered new knowledge for producers to help in their new product development. The new fish product was a classic case of in-depth consumer insight provided via the retailer to the producer to help produce the unique product. The benefits of in-depth consumer insight to product development in the food industry has been well documented (see Costa and Jongen 2006). While this insight provided impetus for the project the technical solutions were provided by suppliers. The specific evidence for the propositions is laid out in Table 5.3.

Table 5.3: Proposition 3 and supporting evidence from case studies

	Propositions	Identified in cases	Evidence of doing, using interacting mode of innovation	Contribution to literature
3.	The DUI mode of innovation within the packaged food sector requires extensive networking activities in order to provide the diverse skills required to develop new knowledge.	Case 1: Fish	"As a retailer we lack the internal capability to undertake packaging development.... [however] the skills of our personnel allow us to work with suppliers to develop new concepts" [RC2].	Support for this proposition will contribute to the specific studies of Parrilli and Heras (2016).
		Case 2: Board	This was a: "joint development project between Chesapeake and a Swedish paper and board materials supplier. The board supplier approached Chesapeake with a newly developed and patented (solid bleach sulphate) board material" [PC2].	
		Case 3: Pouch	"We eventually chose a supplier to focus on a new polymeric formulation technology that would change properties depending on the temperature in which it was stored" [PC2].	
		Case 4: Chocolate	"The confectionary team had been following the progress of a technological development within another regional SBU and identified potential benefits in implementing it into other confectionaries" [BC16].	

5.4 Costs associated with the adoption of new technologies will lead to an emphasis on incremental innovations to meet the existing customers' needs.

Our research shows how food firms recognise that in order to achieve the high returns from investment they have to optimise their processes. For example the milk pouch case illustrated how process change was viewed only in terms of additional costs rather than an opportunity to add value and increase margins. Indeed the packaging producer of pouches conceded that their competitive advantage was being the lowest cost producer but that the further they drive down costs, the more they are tied to the existing format. The food producer's existing customers argue they need lower costs thus reinforcing existing processes (Christensen and Bower, 1996; Cohendet and Llerena, 2010; Malerba, 2010). Here, the technology held the potential to lower costs in the longer term, yet the short-term cost orientation of the retailer hindered its progression. It seems that the price pressure from retailers, and low operating margins, influences technological change within the sector. The specific evidence for the propositions is laid out in Table 5.4.

Table 5.4: Proposition 4 and supporting evidence from case studies

	Propositions	Identified in cases	Evidence of doing, using interacting mode of innovation	Contribution to literature
4.	The anticipated costs associated with the adoption of new technologies will lead to an emphasis on incremental innovations to meet the existing customers' needs.	Case 1: Fish	"It's hard to get categories to adopt new packaging formats . . . managers are under pressure to focus on the day-to-day running, which leads to a lack of focus on the possible returns from a more long-term view on developments" [RC2].	Support for this proposition will contribute to the specific studies of Menrad (2004); Frishammar et al., (2013) and Parrilli and Heras (2016).
		Case 1: Fish	"as the supplier already produced a similar pack for meat they were able to use their existing technologies and production processes with small modifications,... this lowered the costs, which was vital if the format would stand any chance of getting to the shelves" [RC2]	
		Case 2: Board	It was a significant challenge trying to convince the key decision makers that sufficient value could be gained, when compared with the low price commodity packs that were currently commonly used..... Primarily they are interested in cost based process improvements" [PC5].	
		Case 2: Board	"We spend a great deal of R&D time on 'minimising changes to the production line associated with new technologies and lowering costs' [PC2].	
		Case 3: Pouch	"we are a market leader [in the process used for their current packaging format] having driven costs to a minimum over many years, this is a key advantage, but it also constrains us. The further we drive down costs, the more we become tied to our format as the effect on our margin would be significant. . . ." [PC15].	
		Case 3: Pouch	"Our prospective clients typically used cartons or PET bottles.... Any process change was viewed only in terms of additional costs rather than an opportunity to add value and increase margins" [PC7]	
		Case 4: Chocolate	"The new technology improved production speeds, and costs, by removing the need for a time gap prior to coating." [BC15]	
		Case 4: Chocolate	"Another potential solution was to add an inner protective layer of board, but the key decision makers considered too costly." [BC20]	

5.5 Category Management plays a key role in influencing the level of innovation between the retailer and other supply chain members.

The new fish packaging format case illustrates the influence Category Managers have on the level of innovation. In this case the category manager seemed to be overly concerned about negotiating lower prices with suppliers and limited interest in new products. This imbalance seemed to result from the bonus scheme in place, which rewarded short-term cost minimisation but not innovation. In the chocolate bar case the choice of packaging was heavily influenced by the retailer's insistence that the product would be displayed alongside existing products; this hinders scope for change. In these two cases we see the scope of influence of the downstream retailer on technology development. Similarly the milk pouch case showed how the relationship between the preferred supplier (Category Captain) and the retailer determined the selection for the packaging format. This confirms existing findings such as Lindbloom et al. (2009). The retailer viewed packaging specification and associated technologies to be part of the supplier's remit hence any technology change was viewed through the prism of lowering short-term costs. These unique insights on the influential role played by Category Managers in the innovation process contributes to the role played by retailers in innovation theory (Mantrala et al., 2009; and Lager and Frishimmar; 2012). Such an environment limits the ability of technical change even if it may deliver lower costs in the long term. The specific evidence for the propositions is laid out in Table 5.5.

Table 5.5: Proposition 5 and supporting evidence from case studies

	Propositions	Identified in cases	Evidence of doing, using interacting mode of innovation	Contribution to literature
5.	Category Management plays a key role in dictating the level of innovation between the retailer and other supply chain members. The preferred supplier relationship with the category manager determines the nature of innovation.	Case 1: Fish	"The category manager's perspective, as buyers, tends to compound this problem.... They are too heavily focused on negotiating lower prices with suppliers and tend to have limited interest in new innovations, particularly as they can impact on the price we pay for an item, which in some cases could lower their bonuses" [RC2].	Support for this proposition will contribute to the specific studies of Mantrala et al., (2009) and Lager and Frishimmar (2012).
		Case 2: Board	"Category managers are key to initiating most large changes within each category" [PC19].	
		Case 3: Pouch	"Retailers are key decision makers who..... took little interest in speaking to packaging firms, as their remit meant that they viewed packaging specification to be part of the supplier's role... Particularly the preferred supplier can have a significant role to play here on the chosen format of milk packaging...' [P7].	
		Case 4: Chocolate	"Our choice of a flow wrap was heavily influenced by the display and merchandising of the product.... Other formats would require heavy consideration, as they would impact on display. The flow wrap can be displayed alongside our existing products... cutting risk" [BC20].	

This unique insight on the influential role played by Category Managers in the innovation process contributes to the role played by retailers in innovation theory (Mantrala et al., 2009; and Lager and Frishimmar; 2012).

5.6 Extent of STI mode characteristics within cases

The cases were also analysed for evidence of STI mode characteristics (see Table 4). This was necessary as DUI and STI frequently exist together (Jensen et al. 2007). An exploration for

codified or analytical knowledge helped to determine the extent to which the cases illustrate DUI, STI innovation characteristics or combinations of both modes. Table 4 reveals limited evidence of STI mode.

Table 4: Extent of STI mode characteristics within cases

	Company and NPD Project	Extent of STI mode within case. This type of mode generates codified and analytical knowledge (i.e. scientific principles, discoveries, and formulas). (STI) mode supports interactions with centres producing new knowledge, such as research centres and universities
1	UK Food supermarket New Fish product	<p>Consumer research findings led to project idea. This was analytical knowledge produced by an independent Market research Firm, which the retailer subsequently paid to access. The packaging supplier used existing knowledge from other products to recombine in a different way to satisfy project brief. This case illustrates limited codified and analytical knowledge.</p> <p>Evidence of interactions with centres producing new knowledge (such as research centres and universities): None.</p>
2	Packaging company Formable board	<p>The Swedish board supplier developed analytical knowledge in the form of a patent for solid bleach sulphate board material that was able to 'stretch' by between 5-10%. There is evidence of a technology push model here with the supplier searching for applications. The packaging manufacturer had to turn the patent into a 'production ready' product. This involved extensive production line trial and error. This was largely because there were no in-house R&D laboratory facilities available and also because the packaging company wanted to use existing manufacturing processes. This was because of industry knowledge that up-stream partners were reluctant to incur any cost increase. This case illustrates codified knowledge within the patent but the project is mostly about applying this knowledge.</p> <p>Evidence of interactions with centres producing new knowledge: None.</p>
3	Packaging Company Milk pouch	<p>This project was born out of classic recombinations of existing knowledge, such as an existing milk bag for a commercial customer and existing technology for food packaged in 'pouches'. This formed the foundations for the new technology. This was extended by developing a polymer spine that would provide rigidity. The technology for the spine was provided from an existing packaging material supplier that had been developed for another customer in a different industry. This case illustrates little codified and analytical knowledge.</p> <p>Evidence of interactions with centres producing new knowledge: None</p>
4	Food Producer Chocolate bar	<p>This project began life as an internal technology transfer project from another food business unit (BU). The new production technology delivered a faster process by minimising the drying time between cooking the biscuit and coating. The project centres on the ability of the production team to implement the technology into an existing production line setting. This case illustrates little codified and analytical knowledge.</p> <p>Evidence of interactions with centres producing new knowledge: None.</p>

5.7 Extent of project success or failure

The outcomes in each of our cases reveal varying levels of project success, which our framework and propositions help to explain. Table 6 provides an overview of our analysis of failure of the cases. The Fish product was a success, whilst ultimately not marketed by the retailer that initiated the project. This was due to the role of the Category Manager, and his concerns over increased returns for the whole category, and the upfront investment costs involved. Yet its subsequent success with a branded manufacturer provides evidence of the technology's viability. The formable board case was technically successful, and the company is currently in the final stages of negotiation for a contract to supply to a brand owner. Nonetheless

the company experienced significant difficulties in getting a customer to trial or adopt the product. This was due to their concerns over anticipated costs of adoption and uncertainty over demand. Hence the project was placed on hold on two occasions. The milk pouch project was still live at the time of writing this case study, and the packaging supplier experienced difficulties in finding a commercial partner to work jointly on the project and provide the skills required. In this case the upfront capital equipment investments required in new machinery were viewed as too high. The change in format from polythene cartons to pouch was believed to be high risk. While polythene bags have been adopted by commercial food service sector retail buyers and category managers were not convinced consumers would accept the change. Finally, in the case of the chocolate bar it was evident that the lack of concurrent product, packaging and processing development resulted in the development of a bar that could not practically be produced and packaged on the line. This resulted in the project being placed on permanent hold despite the core product technology being market ready. This was because there was a long association with the existing format and there was insufficient input from packaging technologists within the early stages of the project to break the path dependency.

The above findings demonstrate that within three of the cases technical development was successful. Whilst in milk pouch case, technical solutions were available, but limited market interest from the retailers has hindered the progress of the project. In all four cases there were struggles to secure retailer market acceptance. This illustrates the dominant power of the retailer in this sector. Another key influence within the cases was the product manufacturer's sunk capital production equipment costs. This prior investment reinforces incremental change to the existing production line and limits the ability to make or accept radical change in the form of new production equipment. This is a common issue with high volume production environments and frequently leads to path dependency. Indeed Etlie (1983) highlighted this issue in the food industry.

Table 6: Analysis of the extent of failure and success in each of the cases

	Company and NPD Project	Project status	Extent of success/failure	Key causal factors
1	UK Food supermarket New Fish product	-Not launched by retailer originally involved in development. -Launched and success in branded manufacturer.	-Technical success, prototypes tested, but market failure in retailer. -Market success with branded manufacturer.	-Category manager as user insufficiently integrated 'upfront'. -Emphasis on category returns hindered innovation. -Issue with food supplier bearing capital costs key to rejection.
2	Packaging company Formable board	-Developed, range of working prototypes. -Production tooling developed. -Prototypes produced for prospective customer.	-Technical development success. -Project placed on hold on two occasions, due to inability to identify customer. -Currently in final stages of negotiation with branded customer.	-Late market involvement. -Unit costs impede adoption. -Capital costs and anticipated costs both impeded adoption for certain product applications.
3	Packaging Company Milk pouch	-Project presently unsuccessful in identifying an application/customer.	-Technical solutions found based on prior technology. -Project still in progress, but currently unable to achieve market success/identify customer.	-Insufficient upfront user involvement. -Unable to identify lead user or commercial partner. -Customer locked-in to incremental improvement in existing format, this hindered the ability to make a radical change to a new format. -Existing sunk capital equipment impedes adoption of new production technologies. -Dairies unwilling to bear investment costs due to low margins.
4	Food Producer Chocolate bar	-Project placed on hold due to packaging unit costs/unable to identify solution.	-Production of Bar successfully developed. -Packaging development failure, project on hold.	-Running line slower incurred significant cost/efficiency implications. -Lack of iterative & concurrent product, process and packaging development and networking. -Insertion of cardboard sleeve into packaging led to increase in unit costs, which were too high.

6. Discussion and conclusions

Our findings contribute to the stream of literature on innovation within LMT sectors by providing a detailed study of the UK packaged foods sector (Robertson et al., 2009). Previous studies of LMT sectors have been based on large-scale cross-section studies. Our findings identify organisational activities and routines and illustrate the effects in practice of DUI mode of innovation (Jensen et al (2007; Fitjar and Rodriguez-Pose, 2013; Hirsch-Kreinsen et al.; 2005a, b; von Tunzelmann and Acha, 2005). We have shown how the LMT sector of packaged food products utilise the outputs of high-tech (HT) sectors. This provides evidence of how interaction between LMT and HT sectors drives growth.

Taken together our case studies from the packaged food sector provide deep insight into the linkages and relationships which exist amongst a LMT supply chain. Our research supports our five propositions which we developed to examine how DUI effects product and process innovation and the effects of different configurations of DUI practices. Our propositions examined intra-firm and inter-firm processes. Indeed, within all of the case studies there was evidence of the critical role played by middle managers in the form of project leaders as agents of change (Asheim et al., 2005; Jensen et al., 2007). Unexpectedly all four cases show struggles with market entry and this confirms existing research within the food and drinks sectors which has revealed notable product failure rates (Stewart-Knox and Mitchell, 2003; Fuller, 2004). The category managers were shown to be a key market gatekeeper.

Our findings also provide evidence of the generation of new knowledge by firms in a LMT sector. For example, the formable paper board case illustrated the development and production of new designs previously not possible. This was achieved using existing production processes but using a material produced in a novel way giving it unique properties. Even though inputs of new knowledge flow more commonly from sectors classified as high-tech. Older technologies and older knowledge clearly provide vital building blocks for the discoveries of highly innovative firms.

Our analysis of this LMT sector has shed light on the recurring problem of technology diffusion. As far back as the 1960s Thomas Allen recognised the importance of this phenomenon to innovation (Allen, 1968; 1977). Yet diffusion of technology continues to face bottlenecks: with firms with needs unaware of firms with solutions (Hughes, 1992). In addition, our case studies in this paper illustrate that innovation is a multi-stage process that relies heavily on adaptive R&D, with extensions of innovations to multiple uses in multiple sectors. Indeed, we have shown that firms are frequently adapting technology intended for a narrow purpose to their own needs; significant amounts of trial and error takes place on the production line before successful technology change is achieved. This type of creativity and innovation does not fit the definition of R&D that has been developed for statistical surveys and will not show up in indices of research intensity (Patel and Pavitt, 1994; Robertson et al., 2009).

Our case studies show that food processing is the engine room of the packaged food sector. Whether it is processing milk from cows or producing millions of packaged fish meals, this is the NPD part of the value chain. Depending on the category, our cases show how it takes clean, harvested crops or butchered animal products and uses these to produce marketable and often long shelf-life food products. By utilising appropriate food science technologies it helps create yearly availability of many foods and enables transportation of delicate perishable foods. Significantly, it is also the packaging technology that provides this possibility. All four cases provide illustrations of modular combinations of knowledge taking place from different parts of the sector (Henderson and Clark, 1990; Lundvall, 1992; Nonaka and Hirotaka, 1995; Jensen et al 2007; Fitjar and Rodriguez-Pose, 2013). Through DUI activities significant innovation and value is being added at this stage. Our evidence is based on cases from large firms, this reflects the reality in the industry that the largest food and beverage multinationals account for one half of technological activities in the industry worldwide, and influence technological developments throughout the industry, and account for a significant proportion of production (Alfranca et al., 2004; Filippaios et al., 2009). Further, Galizzi and Venturini (2012) suggest that the innovation rate, measured as a comparison of the number of product launches per individual employed, in the food industry is higher within large firms.

Our research provides some preliminary findings and paints a worrying picture of inter-firm supply chain characteristics which appear to be hindering effective DUI mode of innovation. This

is particularly noticeable in food processing as a few factories supply several retailers. Policy makers have been concerned about the role of retailers because so much business goes through relatively few retailers⁵. It is however, the role of category management and its relationship with food processors that appears to be pivotal in innovation and the adoption of technological change. Our research reveals evidence of the influence of Category Management on the innovation process and in particular the role of final arbiter in deciding whether to allow market entry to the consumers (see cases 1, 2 and 3). Further research could explore the extent to which the packaged food sector is a slow adopter of new technologies and the extent to which this is influenced by the retailer.

Our findings also contribute to the literature on 'Hidden innovation' which refers to innovation activities not reflected in traditional indicators such as investment in R&D or patents awarded. This research provides evidence that innovation is indeed occurring but is not being captured in existing innovation metrics (see also Cunningham (2013) for overview of creative industries sector). Further research is required in this underexplored area to help policy makers support these areas which are vital to the future economic growth of economies.

The paper has, of course, its limitations. We cannot claim that the DUI mode of innovation uncovered from our small sample of firms is representative of the whole UK packaged food sector, though there is a *prima facie* case for arguing that the lessons we derive from these examples of LMT innovation and technology change might be. Therefore, while extending recent scholarly work on DUI modes of innovation, the paper has important implications for practice. Current metrics clearly do not recognise levels of creativity and innovation within the industry. To encourage more product innovation incentives and targets for new product introductions could be introduced to category management. Firms need to recognise innovation and technology change relies heavily on their middle managers as project leaders and agents of change, particularly within manufacturing.

There are of course many avenues for further research through which a set of related problems should be investigated in more detail. From a national or regional innovation policy perspective, studies should explore the impact of strategies employed by retailers in the supply chain on levels of innovation. Researchers could examine technology adoption and whether exciting new technologies could be overlooked by the supply chain because of the strategies employed by the big retailers. In addition research could also explore the mutual influence on innovation of consumer sovereignty and competitive retailer innovation.

Comparison is also required with different LMT sectors. Further research is certainly needed to develop evidence, ideally both qualitative and quantitative, on an international comparative basis, which could focus not only on the performance of LMT sectors but also on the geographical distribution of their value chains and economic impact.

For policy makers our cases studies show evidence of DUI in practice of a particular industry sector. Innovation in this sector may be strengthened and deepened with help in the recruitment

⁵ In 2008 the Competition Commission completed its inquiry, concluding that in many respects UK grocery retailers were "delivering a good deal for consumers" but that action was "needed to improve competition in local markets and to address relationships between retailers and their suppliers", including a strengthened and revised Code of Practice, to be enforced by an independent ombudsman. The Groceries Code Adjudicator (or Supermarket Ombudsman) is an individual appointed to regulate the relationship between supermarkets and their suppliers within the United Kingdom. The post was created by the Groceries Code Adjudicator Act 2013 and is an independent office within the Department for Business, Innovation and Skills.

of highly educated personnel, establishing closer links between university and industry and help in building networking competencies.

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Appendix 1: Table 7: Interview respondents

Organisation/ Case	Interview wee Identific ation	Job Position/Role	No. of Interviews	Duration of interviews (minutes)
Food packaging company	PC1	Technical services director	2	90, 58
	PC2	Head of R&D	13	Ranged from 40-125.
	PC3	Sales manager for retailers (own brand)	3	60, 90
	PC4	Sales manager for branded clients	2	55, 70
	PC5	Sales manager for individual client- FMCG and OTC Pharmaceuticals	2	50, 50
	PC6	Design member of R&D team	1	90
	PC7	Marketing Manager	1	120
	PC8	R&D: Technical manager/engineer	3	60, 55, 52
	PC9	Head of Marketing in key supplier and collaborative partner	3	65, 47, 45
	PC10	Industry body representative and partner to firm	2	45, 40
	PC11	Technical packaging manager in top three UK retailer	1	90
	PC12	Head of packaging design, Largest global food and drinks product manufacturer and brand owner	1	96
	PC13	Head of packaging and reprographics at Retailer	2	89, 65
	PC14	Production manager, Dairy supplier.	1	78
	PC15	Technical packaging manager, Top three world foods (snack foods and soft drinks) manufacturer and brand owner.	1	66
	PC16	Marketing manager, Marketing manager for branded milk alternative company	1	55
	PC17	Long range planning manager, Global provider of ingredients and solutions to the food, beverage and other markets.	1	56
	PC18	Category Manager, Top 4 Retailer	1	66
	PC19	Brand Development Manager, Milk Supplier	1	60
	PC20	Packaging innovation manager, Top four UK food retailer	1	85
Food retailer	RA1	Marketing manager	1	90
	RA2	Head of Packaging Innovation	4	88, 90, 55, 45
	RA3	Packaging Technologist	1	75
	RA4	Category Manager	1	62
	RA5	Supplier Project Manager	3	65, 80, 56
	RA6	Category Manager	1	63
	RA7	Former Head of Packaging	2	48
	RA8	Category Manager- Meat and Fish	1	60
Food producer	BC14	Head of Packaging Design	7	Ranged: 68- 180
	BC15	Project Manager	2	72
	BC16	Marketing Manager	1	60
	BC17	Confectionary Brand Manager	1	75
	BC18	Confectionary Technical Development Manager	2	72
	BC19	Member of Design Agency	1	55
	BC20	Marketing Executive	1	83

Appendix 2: Case study protocol and Interview Guide

We constructed a case study protocol using the guidelines of Yin (2003). This was used for each of the individual cases included in the research. The protocol incorporated: an overview of the case project and issues related to the topic being investigated, procedures questions and data collection forms, and a guide for the case report (Yin, 2003). Hence each protocol had information and questions unique to the individual case study. When undertaking the interviews specific questions within the main themes were also tailored to the different actors within each project. We utilised a semi-structured interview approach where each interview was allowed to evolve to allow the following of specific lines of questioning based on the interviewees responses. Subsequent follow-up interviews were undertaken in a number of instances to pursue various themes that had been uncovered in prior interviews or to discuss findings raised by other interviewees.